

BME/MSE 410 Design and Applications of Biomaterials

Semester: Fall, 2015

Days/Times: Monday/Wednesday 10.00-11:30 AM

Classroom: 133 Chrysler

Professor: Geeta Mehta, Ph.D.

Depts. of Materials Science and Engineering, Biomedical Engineering, and Macromolecular Science and Engineering

Office: 2102 H. H. Dow

Office Hours: Immediately after class or via Email

E-mail: mehtagee@umich.edu

GSI: Hong Zhou (hongzhou@umich.edu)

Office Hours: Mondays and Fridays 4-5 pm
2185 LBME Building

Prerequisites: One year of general biology or biochemistry and MSE 220 or 250.

Textbook: Ratner, B. D.; Hoffman, A. S.; Schoen, F. J.; Lemons, J. E., 3rd Eds, *Biomaterials Science: An Introduction to Materials in Medicine*, Elsevier Academic Press, 2012.

ISBN :9780123746269 eBook ISBN :9780080877808

(Book is available online via UMich Library:

<http://mirlyn.lib.umich.edu/Record/012216410>

<http://www.sciencedirect.com/science/book/9780123746269#ancS2>

Pertinent Chapters from Ratner are posted on CTools)

Course website: <https://ctool.umich.edu/>

Useful Websites: • NIH Public Medline: <http://www.ncbi.nlm.nih.gov/PubMed/medline.html>

• The Web of Science Citation Index:

<http://isi10.newisiknowledge.com/portal.cgi>

(need to use from on campus or with your umich username and password)

Accommodations for Students with Disabilities:

If you think you need an accommodation for a disability, please let me know at your earliest convenience. Some aspects of this course, the assignments, the in-class activities, and the way we teach may be modified to facilitate your participation and progress. As soon as you make me aware of your needs, we can work with the [Office of Services for Students with Disabilities \(SSD\)](#) to help us determine appropriate accommodations. SSD (734-763-3000 or ssd.umich.edu) typically recommends accommodations through a Verified Individualized Services and Accommodations (VISA) form. I will treat any information you provide as private and confidential.

I. Course Goals

- 1) Development of global perspective of interdisciplinary issues (biology, materials science, chemistry, and engineering) involved in biomaterials.
- 2) Learn how to design, synthesize, evaluate, and analyze biomaterials.
- 3) Critical thinking and analysis.
- 4) Communication of ideas; communication to coordinate work
- 5) Familiarization with biomaterials literature.

Structure of Lectures

1. Materials (Lectures 1-2)
Bulk properties and surface properties
2. Class of materials used in biomedical applications (Lectures 3 - 12)
3. Biological interactions with materials (Lectures 13 - 22)
Proteins, cells, and tissues
Host reactions: Inflammation, immunology, toxicity, coagulation, and tumorigenesis.
4. Applications of biomaterials (All throughout the course, and Lectures 23 – 26): cardiovascular, orthopedic, dental, skin, functional tissues, etc.)

II. Grading

- (a) 2 midterm exams (**200** pt.; 100 + 100): 20% of grade each
- (b) Homeworks: 15% of grade
- (c) Class Participation: 10% of grade
- (d) Final Exam (**100** pt.): 35% of grade

III Exams: Exams will be split between short-answer type questions and quantitative problems with opportunities for partial credit. Important concepts that might appear on exams will be highlighted in each lecture.

For the midterm exams, I will allow 1 side of 1 equation sheet (8.5x11 inch) (include name neatly) turned in with your exam. This will be returned along with your graded exam.

Final Exam prep: There will be an overall review sessions before the final exam. For the final exam, 2 pages of equation sheets are allowed, and must be turned in with your exam.

Final exam will be cumulative. There will be questions from the guest lecture on the final exam.

IV Homework

HWs discussion with other students in the class: You may discuss HWs with your classmates (it is expected), and work towards solutions together. You must submit individual work that is not a verbatim copy of any other student's work. Do not forget that even when working in groups, you are individually responsible for your learning.

HWs will be collected by the GSI each time they are due, at the beginning of the class.

Late HW Policy:

Same day late HW: 15% deduction

Next day late HW: 50% deduction

Third day late HW: 100% deduction

V Class participation: To ensure active learning and engagement in class, we will be using the iClicker system in lectures. Your personal iClicker must be registered under your username and UMID. Your responses to in-class questions will be recorded via iClicker, and these will go towards your participation points.

We will also conduct active learning exercises during each class. Your participation is essential for these activities, and will count towards your participation points.

VI Course Evaluation: Your feedback is extremely important to make this course better and to improve your learning experience. To encourage course evaluation, I will be awarding extra points:

- If more than 90% of the class completes the final class evaluations, 5 points (from the class participation points) will be awarded to all students.
- With your last homework assignment, staple a receipt of your course evaluation, and you will be awarded an extra 2 points towards your homework points.

Please note that the course evaluations are anonymous and the final evaluations aren't available to me until after your final course grades have been submitted.

VII Journals relevant to Biomaterials

- Minimum you should browse through

Nature

Science

Nature Biotech

Nature Materials

Nature Communications

Proceedings of the National Academy of Science USA (PNAS)

Biomaterials

Tissue Engineering: Part A, Part B, Part C

Journal of the American Chemical Society (JACS)

European Cells & Materials (eCM)

Lab on a Chip

Nanomedicine

Soft Matter

Journal of Biomedical Materials Research Part A

- Others (just some examples, there are more, See Appendix D in Textbook)

Advanced Materials, Advanced Functional Materials, Analytical Chemistry, Annual Review of Biomedical Engineering, Biomacromolecules, Small, Acta Biomaterialia, Cell, Critical Reviews in Biocompatibility

Critical Reviews in Biomedical Engineering
Journal of Biomaterials Science: Polymeric Biomaterials
Journal of Biomedical Materials Research, Journal of Controlled Release
Journal of Long Term Effects of Medical Implants
Journal of Materials Science: Materials in Medicine,

VIII Other Textbooks and References (Also see Appendix D in Textbook)

- Adamson, A. W.; Gast, A. *Physical Chemistry of Surfaces, 6th Ed*, John Wiley & Sons, New York, 1997
- Lodish, G.; Berk, A.; Zipursky, L. S.; Matsudaira, P. *Molecular Cell Biology, 7th Ed*, WH Freeman, 2012
- Alberts, B.; Bray, D.; Lewis, J.; Raff, M.; Roberts, K.; Watson, J. D. *Molecular Biology of the Cell, 5th Ed*, Garland Publishing, New York, 2007.
- Atala, A; Mooney, D. J. Eds *Synthetic Biodegradable Polymer Scaffolds*, Springer Verlag, New York, 1997
- Black, J.; Hastings, G. *Handbook of Biomaterials Properties*, Chapman/Hall, London, 1998
- Janeway, C. A. Jr.; Travers, P. *ImmunoBiology: The Immune System in Health and Disease, 5th Ed*, Garland Publishing, New York, 2001.
- Lanza, R. P.; Langer, R.; Vacanti, J., Eds. *Principles of Tissue Engineering, 2nd Ed.*, Academic Press, San Diego, 2000.
- Park, J. B.; Lakes R. S. *Biomaterials An Introduction, 3rd Ed.*, Plenum Press, New York, 2007.
- Temenoff, J. S.; Mikos A. G. *Biomaterials: The Intersection of Biology and Materials Science*, Prentice Hall, New Jersey, 2008.
- Pruitt L. A.; Chakravartula A. M., *Mechanics of Biomaterials: Fundamental Principles for Implant Design*, Cambridge Texts in Biomedical Engineering, Cambridge University Press, New York 2011

IX Honor Code Statement: All students in the BME/MSE/Macro 410 are presumed to be decent and honorable, and as such, are bound by the College of Engineering Honor Code. You may not seek to gain an unfair advantage over your fellow students; you may not consult, look at, or possess the unpublished work of another without their permission; and you must appropriately acknowledge your use of another's work. Any violation of the honor policies appropriate to each piece of course work will be reported to the Honor Council, and if guilt is established penalties may be imposed by the Honor Council and Faculty Committee on Discipline.

X. Course Outline

#	Date	Topic	Reading	Homework
1	September 9 (Wed)	Orientation and Introduction to Biomaterials	Ratner: pp xxv to xxxvii, xli-lii	
2	September 14 (Mon)	Material Properties, Surface Characterization	Ratner: pp 5-21, 34-59	
3	September 16 (Wed)	Surface Characterization and Polymers	Ratner: pp 34-59, 63-109	
4	September 21 (Mon)	Polymers and Hydrogels	Ratner: pp 63-109, 166-176	HW#1 Due
5	September 23 (Wed)	Hydrogels, Smart Polymers	Ratner: pp 166-176, 247-255	
6	September 28 (Mon)	Medical Fibers and Biotextiles, Biodegradable materials	Ratner: pp 301-319, 179-193	
7	September 30 (Wed)	Biodegradable materials, Natural materials	Ratner: pp 179-193, 195-206	
8	October 5 (Mon)	Natural materials, Surface Modification, REVIEW	Ratner: pp 259-273	HW#2 Due
9	October 7 (Wed)	MIDTERM EXAM During class hours	Lectures 1-8	
10	October 12 (Mon)	Surface Patterning, Metals	Ratner: pp 276-296, 111-159	
11	October 14 (Wed)	Metals, Ceramics and Glasses	Ratner: pp 111-159	
	October 19 (Mon)	STUDY BREAK		
12	October 21 (Wed)	Composites, Pyrolytic Carbon, Porous materials	Ratner: pp 223-237, 209-222, 321-329	HW#3 Due
13	October 26 (Mon)	Cells, Stem Cells, Cell injury response	Ratner: pp 427-451, 487-494	
14	October 28 (Wed)	Proteins on biomaterials	Ratner: pp 394-408	
15	November 2 (Mon)	Proteins on biomaterials, Non fouling surfaces	Ratner: pp 394-408, 241-247	
16	November 4 (Wed)	Cell/tissue biomaterial interactions, Cells and surfaces, Biological response to biomaterials	Ratner: pp 408-422, 452-473, 499-503	HW#4 Due
17	November 9 (Mon)	Biological response to biomaterials, Inflammation and immunity, REVIEW	Ratner: pp 499-503, 503-532	
18	November 11 (Wed)	MIDTERM EXAM During class hours	Lectures 10-17	
19	November 16 (Mon)	Adaptive Immunity, Toxicity, Hypersensitivity, Tumorigenesis	Ratner: pp 545-565	

20	November 18 (Wed)	Clotting and Unclotting, Blood-Material interactions, Biofilms	Ratner: pp 551-558, 565-576,	HW#5 Due
21	November 23 (Mon)	Biological testing of biomaterials	Ratner: pp 587-633	
22	November 25 (Wed)	Degradation of materials in the biological environment, Pathological Calcification	Ratner: pp 695-750, 739-754	
23	November 30 (Mon)	Cardiovascular Applications	Ratner: pp 760-809	
24	December 2 (Wed)	Cardiovascular Applications, Orthopedic Applications	Ratner: pp 760-809, 841-878	HW#6 Due
25	December 7 (Mon)	Orthopedic and Dental Applications	Ratner: pp 841-878, 882-888	
26	December 9 (Wed)	Adhesives, Sealants, Sutures, Skin Substitutes	Ratner: pp 889-905, 1006-1023	
27	December 14 (Mon)	Overall Course Review		